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Challenges for Beekeeping in Indonesia with Autochthonous and Introduced Bees

Kristina Gratzner, Fajar Susilo, Dwi Purnomo, Sascha Fiedler and Robert Brodschneider 

The current beekeeping situation in Indonesia

Indonesia has a surface area of 1.91 Mkm² and with its more than 18,000 islands and ~113 Mha (2010) of forest area, the country harbors flora and fauna rich in diversity (Abood, Lee, Burivalova, Garcia-Ulloa, & Koh, 2015; Cribb & Ford, 2009; Hansen et al., 2013; United Nations, 2018). The remarkable diversity is also reflected by the number of bee species. Thus, 8 out of 9 species of the genus *Apis*, with *Apis laboriosa* as the only absent one, as well as more than 40 stingless bee species were observed in Indonesia (Gupta, Reybroeck, van Veen, & Gupta, 2014; Hadisoesilo, 2001; Hadisoesilo et al., 2008; Kahono, Chantawannakul, & Engel, 2018; Koeniger, Koeniger, & Tingek, 2010; Rasmussen, 2008; Roubik, 2005; Tanaka, Roubik, Kato, Liew, & Gunsalam, 2001; Theisen-Jones & Bienefeld, 2016).

It has been estimated that 66% of the world's crop species are pollinated by bees, including honey bees, bumble bees and solitary bees (Kremen, Williams, & Thorp, 2002; Partap, 2011). Beekeeping not only positively contributes to income gain, it also plays a role in increased food security, but beekeeping activity and its potential receives only subordinate attention within the Indonesian government and population. According to scientists from the Universitas Padjadjaran (UNPAD, Bandung, Indonesia), bee businesses are mostly considered as a part time farming activity and not only parts of the local community, but people from every social class are not aware of the bees' benefits (Chantawannakul, Williams, & Neumann, 2018). As found in a survey by UNPAD and CV. Primary Indonesia

(Labtek Indie), among 80 citizens 57.5% had certain prejudices against bees. Those range from insufficient profitability, to fear of bee stings, to a lack of knowledge on the importance of bees as pollinators. Furthermore, there are field owners fearing bees have a negative impact on their crops' productivity. They do not want bees or beehives near their property and in a consequence some of them are willing to burn those colonies, if verbal warnings were ignored by the beekeepers. Indonesia is the 4th most populous country worldwide with a population that reached 264 million in 2018 (FAOSTAT, 2018). The population growth is accompanied by a significant stress for the Indonesian ecosystem and a continuous increase of used land area, triggered by rising demands of natural resources like timber and food (Abood et al., 2015). To antagonize the existing trend, beekeeping can be used to sensitize the population towards the importance of forest conservation and non-timber materials.

So far, local beekeepers use mostly native honey bee species like *Apis cerana* or Meliponini colonies for managed beekeeping (Figure 2) (Schouten, Lloyd, & Lloyd, 2019), but it is also common to practice the art of honey hunting from wild living, so far not-manageable, *Apis dorsata* colonies (Crane, Van Luyen, Mulder, & Ta, 1993; Gupta et al., 2014). Besides honey hunting and beekeeping, Bradbear and FAO (2009) defined a third type of apicultural activity: "Bee maintaining"; an intermediary stage of beekeeping, where humans safeguard wild living colonies. The colonies are not kept in hives, but honey collectors often provide artificial nesting places, for example traditional *tikung*, *tingku* or also called *sunggau*

(wooden honey boards or tree trunks) (Hadisoesilo, 2002). A similar method to maintain *A. dorsata* colonies, observed in Indonesia and elsewhere in South-East Asia, is the use of special rafters (Bradbear & FAO, 2009; Crane et al., 1993). *Tikungs* are trapezium shaped boards often made from banyan (*Ficus benghalensis*) wood, which are placed between tree branches to attract feral *A. dorsata* colonies. If the *tikung* is occupied, the bees build their nest on it while they forage on the same and on neighboring trees in flower. Harvesting takes place during the rainy season and honey collectors cut only the top of the honey containing part of the comb to protect the brood and to maintain the colony. To obtain the honey and separate it from beeswax, it is not common to squeeze, but gently let the honey flow through filter fabric (WWF, 2010) (Figure 1). Once a *tikung* is occupied by a swarm, it is believed, that the same colony remigrates to it every year (Paar, Oldroyd, Huettinger, & Kastberger, 2004). This method may be a good alternative to the less secure and more common practice of honey hunting and is also used in other Asian countries (de Jong, 2000; Mahindre, 2000).

To demonstrate the potential of wild honey production with *tikungs*, the Sentarum Lake Beekeeper Association (APDS), consisting of 217 beekeepers, recorded wild honey harvests. This was 4.3 t in 2007 and even reached 16.5 t in 2008 to 2009. The total potential honey production for this area is estimated to reach 30 t per year (WWF, 2010).

There are only cryptic amounts of literature available on apiculture in Indonesia. Within the European Union's Horizon 2020 project SAMS ("Smart Apiculture



Figure 1. Harvesting of wild honey in Semanggit Village, Selimbau District, Kapuas Hulu Regency, West Kalimantan, Indonesia. (a) Honey collector climbs the tree to reach the prior installed tikung; (b) only the top of the honeycomb is harvested; (c) smoke producing tool for calming feral bees; (d) filtering process of harvested honey. Photos by Yohanes Kurnia Irawan, used with permission.

Management Systems”), a review of literature was conducted, and information was summarized in a growing Wikipedia-like database (<https://wiki.sams-project.eu>). For example, no official key numbers representing colony numbers for the whole country are available, but only limited datasets: e.g. in West Java, 7,141 *Apis mellifera* hives were managed and 35.8 t of honey were produced in this area in 2016 (UNPAD, personal communication). Unfortunately, there are no hive numbers for the more commonly kept *A. cerana* bees.

Conforming to data on honey import and export available from FAOSTAT (2018), Indonesia can be regarded as a net importer of honey (mostly from Asia). In detail, honey export in 2013 reached 207 t and 2.35 million USD, while 2,177 t of honey (8.33 million USD) were imported within the same year (FAOSTAT, 2018). According to UNPAD, in 2018 high quality honey offered on the domestic market was sold for a prize of 200,000 Rupiahs (~14 USD). Nevertheless, the majority of the sold honey is considered from lower quality, containing often more than 25% of moisture and the alteration with sugar syrup is also a common problem (White, Platt, Allen-Wardell, & Allen-Wardell, 1988). The honey bee product yield is low due to a lack of beekeeping know-how and other factors like the absconding behavior of native bees, bee forage availability, and the indiscriminate use of pesticides (Amir & Pengembangan, 2002; Oldroyd & Nanork, 2009).

Little information is given on commonly applied treatments against honey bee pests and pathogens and no national honey bee health program exists. Besides the knowledge on the presence of parasitic mites (Anderson, 1994; Diao et al., 2018; Rosenkranz, Aumeier, & Ziegelmann, 2010), information on the national distribution of organisms affecting honey bee health is completely missing (Ellis & Munn, 2005).

Western honey bee vs. Eastern honey bee

There is no agreement on the exact introduction date of *A. mellifera* to Indonesia. Either way, there is evidence of several unsuccessful trials of bringing the Western honey bee into the country, before it was successfully introduced in Java in the second half of the 20th century, probably in 1967 or 1972 (Engel, 2012; Hadisoelilo, Shanti & Kuntadi, 2002). As a consequence, *A. mellifera* spread all over the island, and until today the majority of *A. mellifera* apiaries are still found in this area (Kahono et al., 2018). Morphological and genetic studies are needed to identify the origin(s) of the introduced *A. mellifera* subspecies. Numerous beekeepers all over Asia believing in the advantages of *A. mellifera* are willing to give up beekeeping with *A. cerana*. A survey by Theisen-Jones and Bienefeld (2016) revealed that in Indonesia the remaining percentage of managed *A. cerana* lays between 45% and 60% (compared to introduced *A.*

mellifera), while native species getting more and more replaced by the introduced *A. mellifera* all over Asia (e.g., in Thailand beekeeping with *A. cerana* decreased by 95%). Due to the archipelago structure of Indonesia, those numbers may vary strongly between regions and islands.

Both mentioned *Apis* species do have their advantages for managed beekeeping. The colony size of *A. cerana* ranges from 2,000 to 20,000, while *A. mellifera* colonies reach between 30,000 and 50,000, latter have higher productivity and therefore the harvesting of honey bee products is more profitable (Crane, 1990). The higher productivity of *A. mellifera* is based on its survival strategy to hoard as much honey as possible to ensure the survival of the colony in times of food shortage (winters, droughts, excessive rainfalls) (Crane, 1984). *A. cerana* follows a different strategy by having a high tendency to abscond in periods of unfavorable environmental conditions (triggered by tropical climate, pressure of pathogens/pests/predators, or insufficient forage-opportunities). Consequently, *A. cerana* does not store large amounts of honey (Koetz, 2013). Differences in the foraging behavior between the two *Apis* species are also observable, with *A. mellifera* having a wider foraging range, than *A. cerana* (Couvillon & Ratnieks, 2015; Koetz, 2013). Nevertheless, the Eastern honey bee is an excellent pollinator.

Apis mellifera and *Apis cerana* drones are attracted by similar pheromones secreted by the particular queen. Mating between species is possible, but hybridization blocks, such as morphological differences in reproductive organs, may result in reproductive failure (Ruttner & Maul, 1983). Considering the lower colony size of *A. cerana*, they are more affected by interspecific mating and are less capable of complementing high drone losses (Moritz, Härtel, & Neumann, 2005). Due to the higher aggressiveness of *A. mellifera*, they are often more successful in robbing honey from other honey bee species and subspecies than *vice versa*, which could lead to damage of autochthonous colonies (Chantawannakul, Petersen, & Wongsiri, 2004; Oldroyd & Nanork, 2009).

The question is, regarding the consequences of the long-term costs of replacing *A. cerana* colonies, is *A. mellifera* really the better alternative for future beekeeping in Indonesia? Oldroyd and Nanork (2009) do not believe in a severe impact of *A. mellifera* on *A. cerana*



Figure 2. (a) and (b) *Apis cerana* housing hives on stands, a technique to reduce the risk of predation (ants, lizards, foxes, etc.); (c) a frame including *Apis cerana* brood, honey and pollen; (d) sun melting pot to separate wax from honey and to reduce honey's water content; (e) and (f) managed beehiving with stingless bees (*Trigona* sp.). Locations for Figures (a), (c), (e), (f) at Gunung Arca Apiary Center, Sukabumi, West Java, Indonesia. Locations for figures (b) and (d) were situated in Bandung, West Java, Indonesia. Photos by Sascha Fiedler.

colonies, because feral *A. mellifera* colonies in Asia, which would also include Indonesia, are so far unknown. This fact may have different reasons: the climate of the tropics brings only minor variation in day length and thus, Western honey bees cannot further adapt on these conditions (e.g., brood production). In comparison, feral *A. mellifera* may be only a question of time, if there are efforts to introduce African *A. mellifera* subspecies that are adapted to tropical climate (Moritz et al., 2005).

In Indonesia, *A. mellifera* is mostly put in context with migratory beekeeping, but this practice is not widely used and underdeveloped (UNPAD, pers. communication). Widiarti and Kuntadi (2012) conducted an interview-based study in

Central Java and identified the major constraints of developing migratory beekeeping with *A. mellifera* resulting in a shortage of bee forage, capital, extension, technical training and workshops, as well as breeding and honey bee health issues (pests, pathogens). Besides, existing prejudices among the Indonesian population may also be an important contributing factor to the unpopularity of this beekeeping practice.

One special phenomenon, negatively affecting the bee forage availability, was described by the Ministry of Agriculture in 2011: a change in market trend from traditional kapok to modern mattresses led to a significant decrease of the kapok tree population, namely 44% from 2000 to 2009. Kuntadi (2008) further revealed a

10.2% decline of kapok trees in the migratory beekeeping region East Java Province. Kapok trees serve as important forage plant for bee species and especially for beekeepers using *A. mellifera* for migratory beekeeping the plant is valuable.

Performing migratory beekeeping in Indonesia is not easy and financial costs are high. The biggest expenses in managing *A. mellifera* are transportation and the purchase of sugar. One colony needs at least 1 kg of sugar per month during the drought season, which may occur up to 5 months (December to April). In Java, beekeepers use a similar migratory route (from West and East, to Central Java) and therefore the competition for the best forage sites is high. Those differ in food availability and therefore bee colonies often need supplemental feeding and cause financial penalties. In a consequence, some beekeepers who fail to reach their production target sell their hives after the season. To promote the development of migratory beekeeping in Indonesia, it is suggested to increase the availability of natural bee forage, and to establish governmental regulations for colony migration and logging policies.

Krongdang, Evans, Chen, Mookhploy, and Chantawannakul (2018) compared the susceptibility of *A. mellifera* and *A. cerana* against *Paenibacillus larvae*, the causative agent of American Foulbrood, and found a higher immune response, reflected by increased gene expression levels of antimicrobial peptides (AMPs), in the Eastern honey bee. Honey bees produce AMPs in response to pathogens and parasites and therefore the monitoring of AMP gene expression acts as a suitable tool for studying innate immunity. In general, *A. cerana* has a higher disease-resistance, particularly against parasitic mites, but seems to be more sensitive to Thai Sac Brood Virus (Theisen-Jones & Bienefeld, 2016). Increased hygienic standards (bees clean themselves and others at higher frequencies, infected brood is removed before sealing the brood cells) positively contribute to the higher resistance and therefore the treatment with acaricides against *Varroa* infestation is not necessary, which results in less needed equipment, knowledge and time effort for the beekeeper (Boecking & Spivak, 1999). *A. cerana* bees have further advantages: they are known to have a gentle temperament, they do not necessarily need supplementation if forage is available year-round, they need less foraging areas, and if well-acclimated, they react less sensitive to changes in climate conditions and are able to forage under

more unfavorable conditions (Koetz, 2013; Oldroyd & Nanork, 2009; Theisen-Jones & Bienefeld, 2016). In contrast to this, survival of *A. mellifera* is impacted if *Varroa* or *Tropilaelaps* spp. infestations stay untreated. The tropical weather conditions may also lead to decreased foraging behavior of *A. mellifera* and in a consequence to greater demand of supplemental feeding (Theisen-Jones & Bienefeld, 2016).

The shifting from dry to rainy season and the decrease of natural bee forage is a challenge for beekeepers and their bee colonies and demands proper bee management, such as offering the right supplemental food. Kuntadi (2008) compared three different soybean flours (roasted, boiled and fermented with peeled bean) as protein supplement. The results indicated that soybean flour processing influences the protein uptake of honey bees. Specifically, the bees preferred boiled and fermented (with peeled bean) soybean flours over the roasted one. The processing method of the protein supplement did not affect the mortality of bees neither the honey bee colony size.

Preservation issue of autochthonous *Apis* species

As studies on *A. mellifera* in Indonesia are exceptional, information on a possible impact of local climate and flora on *A. mellifera* beekeeping and its profitability is missing. It has to be mentioned, that before the selection of desired traits, *A. mellifera* produced, similar to *A. cerana*, only 2–5 kg honey per colony (Theisen-Jones & Bienefeld, 2016). Hence, it is very likely that selective breeding of *A. cerana* will also result in higher honey yield per colony. This may be a possible compromise that favors beekeeping with, and therefore the preservation of *A. cerana*. Of course, in a country with numerous amounts of feral *A. cerana* colonies, there will always be interactions with their hived sisters and therefore proper breeding programs are not easy to initiate and need adequate governmental, non-governmental and scientific support. Another alternative of preserving autochthonous bee species is focusing on *A. dorsata*. Several projects exist, aiming to encourage the people of Indonesia to harvest honey not from *A. cerana*, but from *A. dorsata* nests, rather than changing to beekeeping with *A. mellifera*. Provided, honey hunting is practiced in a sustainable and hygienic way: only harvest the honeycombs instead of destroying the whole nest, wearing protective clothes, or

filtrating the honey through simple closed mashed nets (Oldroyd & Nanork, 2009). Native bee species are known to be more resistant against pests and pathogens, while beekeeping with the Western *A. mellifera* implicates regular hive-inspection and management as well as larger foraging areas to successfully harvest large amounts of honey and other honey bee products and therefore is more time-consuming and requires more knowledge (Chantawannakul et al., 2004; Theisen-Jones & Bienefeld, 2016). Nevertheless, if the beekeepers are proper trained, the higher amount of invested time is relativized with the higher productivity of *A. mellifera* that leads to a significantly higher income of beekeepers.

Conclusions

Strengthening the beekeeping sector in Indonesia leads not only to improved protection of the environment but also to an increased quality of life and income. Better living standards may be achieved by marketing bee products, or by improved yields of agricultural goods. Thus, it is important to spread the word on the importance of bees and beekeeping within the government and the Indonesian population. Besides convincing the citizens, it is also important to train beekeepers and extension workers in business and beekeeping relating topics and to conduct field research on honey bee health, disease recognition, and dissemination of control methods. The knowledge about beekeeping with the indigenous honey bee species *A. cerana* already exists (Schouten et al., 2019), while in Indonesia beekeeping with introduced *A. mellifera* is often limited to the still underdeveloped migratory beekeeping practice. Both bee species have their advantages and in the end, this literature based study gives no ultimate answer on which one should be encouraged for beekeeping in Indonesia, but it has to be mentioned that “poor people should not be expected to bear the burden of conservation, which is the responsibility of us all” (Oldroyd & Nanork, 2009).

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